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IMPACT PICTURE AND DIFFRACTIVE DISSOCIATION

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Abstract

Based on the impact picture, we give quantitative predictions on the following three reactions: (i) $p + p \rightarrow p + N^*(1470)$; (ii) $\pi + p \rightarrow \pi + N^*(1470)$; and (iii) $K + p \rightarrow K + N^*(1470)$. Factorization is predicted to be approximately valid except near the dip in reaction (i).

With the increase of the pp total cross section observed in the ISR,¹ the impact picture^{2,3,4} has passed a preliminary test. It is now important to see if the other predictions of the impact picture stand the trial of experiments as well. In this paper, we explore the processes of diffractive dissociation, and make quantitative predictions on the differential cross sections of the following three reactions: (i) $p + p \rightarrow p + N^*(1470)$; (ii) $\pi + p \rightarrow \pi + N^*(1470)$; and (iii) $K + p \rightarrow K + N^*(1470)$.

The amplitude for two-body diffractive dissociation processes at high energy is given by:⁴

$$M(s, \vec{\Delta}) = \frac{is}{2\pi} \int d\vec{x}_\perp e^{-i\vec{\Delta} \cdot \vec{x}_\perp} D(S, \vec{x}_\perp), \quad (1)$$

where S is defined below and $\vec{\Delta}$ is the momentum transfer. As was discussed in Reference 4, D vanishes in the black core and is appreciable only in the gray fringe. As the simplest model for a phenomenological fit, we choose:

$$D(S, \vec{x}_\perp) = C SF(x_\perp^2) \exp[-SF(x_\perp^2)], \quad (2)$$

with

$$F(x_\perp^2) = f \exp[-\lambda(x_\perp^2 + x_0^2)^{1/2}] \quad (3)$$

and

$$S = (Ee^{-\frac{i\pi}{2}})^c. \quad (4)$$

In the above, the numbers c and λ are channel independent and have been determined by our earlier fits of elastic scattering to be:

$$c = 0.08 \quad (5)$$

$$\lambda = 0.60 \quad (6)$$

The numbers x_0 and f are channel dependent. We shall make the assumption that x_0 and f are the same as those in elastic scattering.

Thus there is only one number, C , to be determined. Since C appears as a multiplicative constant, the shapes of the differential cross sections for reactions (i), (ii), and (iii) are entirely determined by our earlier fits of elastic scattering. We also call attention to the fact that c as given by (5) is an effective value, as logarithmic factors of s have been ignored to retain simplicity. From a purely theoretical basis, (4) should be replaced by:²

$$S = \frac{(se^{-i\pi})^c}{[\ln(se^{-i\pi})]^{c'}} + \frac{s^c}{(\ln s)^{c'}} \quad (7)$$

If we choose $c' = 1$, as supported by some field theoretic models, then c is about 0.2. However, the fits obtained in these two choices have only slight differences. Thus we shall, for simplicity, adopt $c' = 0$ here. A more complete fit will be reported elsewhere.

Figure 1 (a), (b), and (c) show the predicted cross sections $d\sigma/dt$ for the reactions (i), (ii), and (iii). Figure 1(a) shows the experimental data⁶ for the reaction:

$$p + p \rightarrow p + N^*(1400).$$

The calculated curve is for the reaction:

$$p + p \rightarrow p + N^*(1470);$$

and we have normalized the cross section by choosing C^2 equal to 0.1. The $N^*(1400)$ is shifted in mass relative to the $N^*(1470)$ which is well established in pion nucleon phase-shift analysis. The explanation for this mass shift is not clear. However, if our identification of these two resonances being the same particle is correct, then the steep slope ($b \sim 15$) observed for this reaction is accounted for in the present model. We predict a dip in the cross section at $|t| = 0.5$ and furthermore a slow movement of the dip position as the energy is increased. Comparison of Figs. 1(b) and 1(c) show that we expect the slope of $d\sigma/dt$ for reactions (ii) and (iii) to be less than for reaction (i). In addition we predict the existence of structures in reactions (ii) and (iii).

We turn our attention now to discuss factorization in these reactions. In the impact picture the pomeron singularity in the complex angular momentum plane does not lead to exact factorization. On the other hand, there is experimental evidence that indicates that, for total cross sections, factorization works to about 20% in several reactions. Therefore, it is a quantitative question to ask whether the present model is consistent with this small violation of factorization. In addition we inquire if there are any regions of the kinematic variables where factorization is predicted to be badly violated.

We have calculated the ratios of the following reactions:

$$R(pp) = \frac{p + p \rightarrow p + p}{p + p \rightarrow p + N^*(1400)}$$

and similarly for the πp and Kp channels to obtain $R(\pi p)$ and $R(Kp)$.

If factorization is valid then

$$\mathcal{R} = \frac{R(pp)}{R(Kp)} = \frac{R(\pi p)}{R(Kp)} = 1.$$

Figure 2 shows the predictions of the model as a function of momentum transfer $|t|$. It can be seen that at small $|t|$ the model predicts that to within about 5 to 10% factorization should hold. At larger $|t|$ factorization continues to be good for the πp to Kp comparison. However, in the pp to Kp comparison there is an increasing degree of violation of factorization. Because the differential cross sections are heavily weighted to small $|t|$, the integrated cross sections are predicted to satisfy factorization to about 10%. Thus, the model predictions are in good accord with experimental checks of factorization for integrated cross sections. However, it is predicted that in the region of the dip in pp diffraction scattering, which should develop around $|t| \approx 0.5$, factorization fails drastically.

All of these three reactions can be studied using the high resolution strong focusing spectrometer presently being constructed in the Meson Laboratory of the National Accelerator Laboratory, and it appears that an encounter of our results with experiments may be realized in the not too distant future.

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FIGURE CAPTIONS

Fig. 1(a), (b), (c) Diffractive inelastic scattering for the three reactions $p + p \rightarrow p + N^*(1400)$, $\pi + p \rightarrow \pi + N^*(1400)$, and $K + p \rightarrow K + N^*(1400)$. The curves are predictions of the impact picture with parameterization given in the text. The two energies in Fig. 1(a) cover the range accessible at the ISR. The two energies in Figs. 1(b) and 1(c) cover the range available at the National Accelerator Laboratory.

Fig. 2 The impact picture prediction for $\mathcal{R} = \frac{R(hp)}{R(Kp)}$ is plotted versus momentum transfer $|t|$ for $s = 100 \text{ GeV}^2$. $R(hp)$ is defined as the ratio of the elastic to diffractive inelastic channel for an incident hadron, h , where h can be a proton or pion.

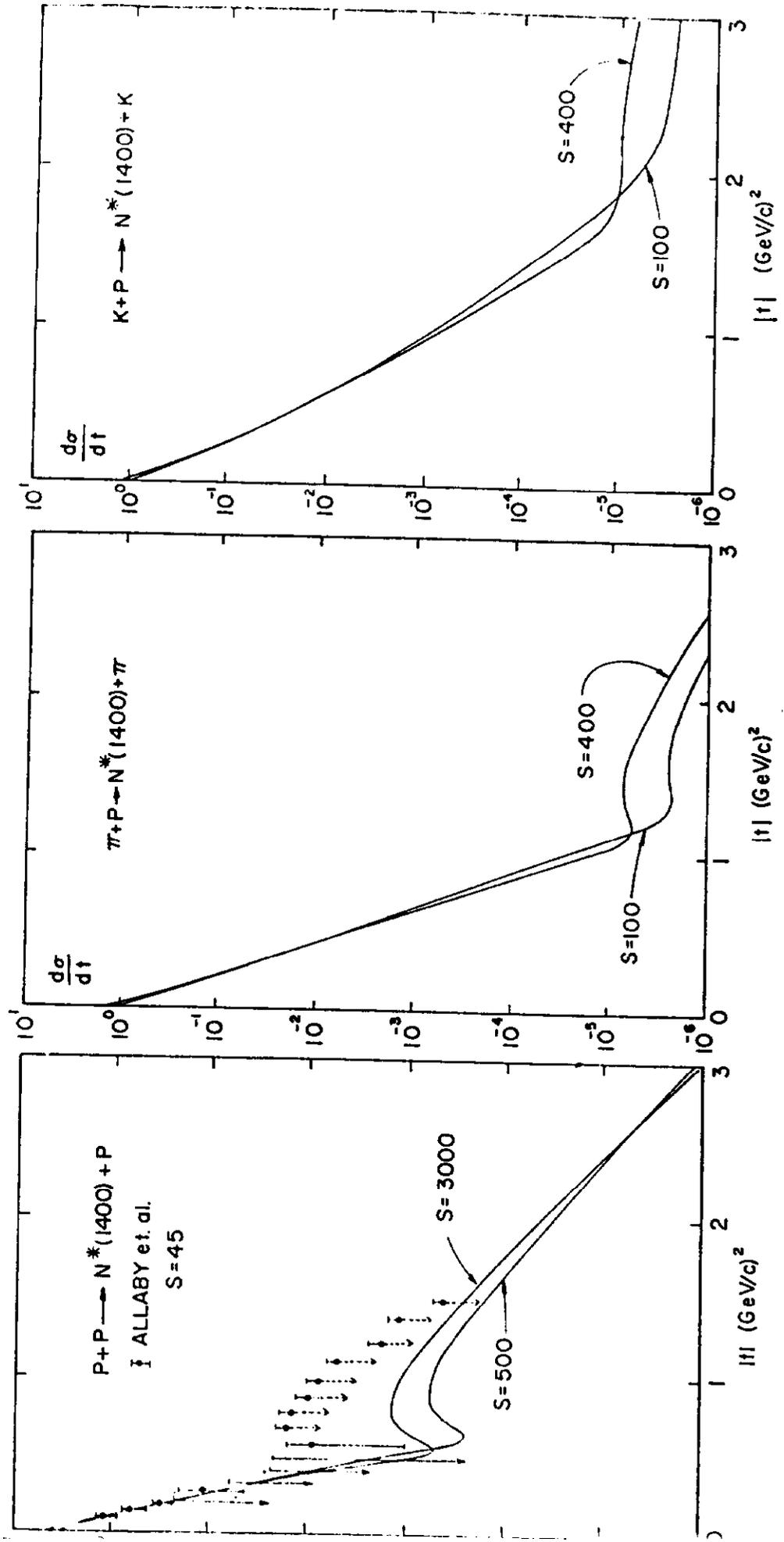


Fig. 1

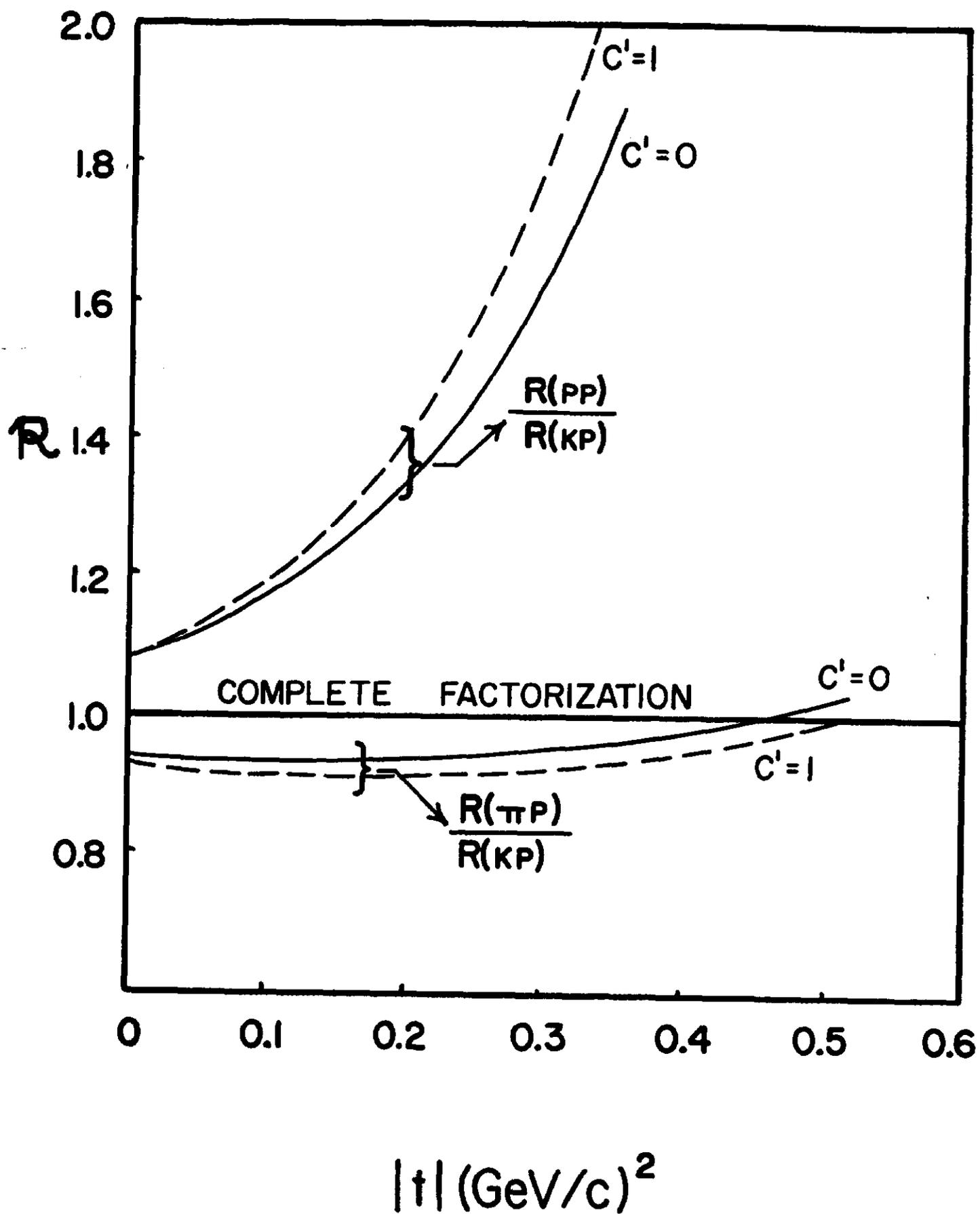


Fig. 2